

What is claimed is:

1. A distortion correction device, comprising:

an outline extraction device extracting regular  
5 graphics attached to a piece of rectangular paper from  
an input image obtained by photographing the paper;

a curved-surface estimation device estimating  
a three-dimensional curved-surface model of the paper  
using distortion of the regular graphics as a clue;  
10 and

a distortion correction device correcting the  
distortion based on the three-dimensional  
curved-surface model and outputting a corrected image  
as an output image.

15

2. A distortion correction device, comprising:

an outline extraction device extracting an  
outline of a piece of rectangular paper from an input  
image obtained by photographing the paper;

20 a curved-surface estimation device estimating  
a three-dimensional curved-surface model of the paper  
using distortion of the outline as a clue; and

a distortion correction device correcting the  
distortion based on the three-dimensional  
25 curved-surface model and outputting a corrected image

as an output image.

3. A distortion correction device, comprising:

an outline extraction device extracting  
5 horizontal and vertical lines written in a piece of  
rectangular paper from an input image obtained by  
photographing the paper;

a curved-surface estimation device estimating  
a three-dimensional curved-surface model of the paper  
10 using distortion at an intersection of the horizontal  
and vertical lines written in the paper as a clue; and

a distortion correction device correcting the  
distortion based on the three-dimensional curved-  
surface model and outputting a corrected image as an  
15 output image.

4. A distortion correction device, comprising:

an outline extraction device extracting  
horizontal and vertical character strings written in  
20 a piece of rectangular paper from the input image  
obtained by photographing the paper;

a curved-surface estimation device estimating  
a three-dimensional curved-surface model of the paper  
using distortion at an intersection of the horizontal  
25 and vertical character strings written in the paper

as a clue; and

a distortion correction device correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an  
5 output image.

5. A distortion correction device, comprising:

an outline extraction device extracting an outline of a piece of rectangular paper from an input  
10 image obtained by photographing the paper; and

a distortion correction device correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image.

15 6. A distortion correction device, comprising:

a curved-surface estimation device obtaining outline information about a piece of rectangular paper and estimating a three-dimensional curved-surface model of the paper using outline distortion obtained  
20 from the outline information as a clue; and

a distortion correction device correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

7. A distortion correction device, comprising:

an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;

5 a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the outlines; and

a distortion correction device correcting distortion using distortion of the outline as a clue  
10 and outputting a corrected image as an output image.

8. The distortion correction device according to claim 7, wherein the input and output images are one of a white-and-black binary image, a gradation image and  
15 a color image.

9. The distortion correction device according to claim 7, wherein said outline extraction device evaluates outline likeliness indicating a ratio between both  
20 series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge  
25 extraction for the input image, and selects a likelier

outline pixel candidate as an outline pixel.

10. The distortion correction device according to claim  
7, wherein said outline extraction device evaluates  
5 outline likeliness indicating a ratio between both  
series of pixel strings with color of an external area  
of the paper and series of pixel strings with color  
of an internal area horizontally or vertically  
including a target pixel, out of outline pixel  
10 candidates obtained by performing edge extraction for  
the input image, and selects a likelier outline pixel  
candidate as an outline pixel.

11. The distortion correction device according to claim  
15 10, wherein said outline extraction device uses a value  
obtained by performing a product sum of a pixel value  
arbitrarily extracted from the neighborhood of the  
outline pixel candidate horizontally or vertically  
including the outline pixel candidate and  
20 appropriately set fixed-value vector, as the outline  
likeliness.

12. The distortion correction device according to claim  
11, wherein said outline extraction device uses a value  
25 obtained by performing a product sum of both a

horizontally symmetrical mask  $k, k, k, \dots, k, 0, -k, \dots, -k, -k, -k$  and a vertically symmetrical mask  $k, k, k, \dots, k, 0, -k, \dots, -k, -k, -k$  arrayed horizontally and vertically, respectively, including the outline pixel candidate using  $k$  as a positive or negative constant with value 0 at a center, as the outline likeliness.

13. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a sunken center-folded three-dimensional curved-surface model obtained by modeling sunken center-folded distortion as the three-dimensional curved-surface model.

14. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a raised center-folded three-dimensional curved-surface model obtained by modeling raised center-folded distortion as the three-dimensional curved-surface model.

15. The distortion correction device according to claim 14, wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical

pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

16. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a raised circumference distortion three-dimensional curved-surface model obtained by modeling raised circumference distortion as the three-dimensional curved-surface model.

17. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a curved-surface model obtained by applying linear Coons interpolation to a three-dimension outline model obtained by modeling a three-dimensional outline of the paper as the three-dimensional curved-surface model.

18. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses points on a three-dimensional outline as three-dimensional discrete sample points of the

three-dimensional outline model and a value corresponding to height of each of the three-dimensional sample points as a model parameter.

5 19. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses a curved model with a parameter as the three-dimensional outline model.

10 20. The distortion correction device according to claim 19, wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by expressing a restriction that all curves with the same X-coordinate or Y-coordinate have the same length with  
15 an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

20 21. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses values corresponding to height of two end points of a three-dimensional outline as model parameters of the three-dimensional outline model and restricts a  
25 location on a condition that points on a



three-dimensional outline are on a vertical plane, including a three-dimensional line segment connecting the two end points.

- 5 22. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses a three-dimensional line segment as the three-dimensional outline model.
- 10 23. The distortion correction device according to claim 7, wherein said curved-surface estimation device estimates a three-dimensional curved surface by estimating a three-dimensional outline by perspective conversion using the extracted outline as a clue.
- 15 24. The distortion correction device according to claim 7, wherein said distortion correction device calculates a location in the input image, corresponding to each pixel of an image after correction using a curved coordinate system with the outline as a coordinate axis and obtains an image after correction with length of top/lower outlines and length of left/right outlines as width and height, respectively, by setting a value of a corresponding pixel in the input image as a target
- 20 pixel value of the image after correction.
- 25

25. A distortion correction method, comprising:

extracting regular graphics attached to a piece  
of rectangular paper from an input image obtained by  
5 photographing the paper;

estimating a three-dimensional curved-surface  
model of the paper using distortion of the regular  
graphics as a clue; and

correcting the distortion based on the  
10 three-dimensional curved-surface model and outputting  
a corrected image as an output image.

26. A distortion correction method, comprising:

extracting an outline of a piece of rectangular  
15 paper from an input image obtained by photographing  
the paper;

estimating a three-dimensional curved-surface  
model of the paper using distortion of the outline as  
a clue; and

20 correcting the distortion based on the  
three-dimensional curved-surface model and outputting  
a corrected image as an output image.

27. A distortion correction method, comprising:

25 extracting horizontal and vertical lines written

in a piece of rectangular paper from an input image  
obtained by photographing the paper;

estimating a three-dimensional curved-surface  
model of the paper using distortion at an intersection  
5 of the horizontal and vertical lines written in the  
paper as a clue; and

correcting the distortion based on the  
three-dimensional curved-surface model and outputting  
a corrected image as an output image.

10

28. A distortion correction method, comprising:

extracting horizontal and vertical character  
strings written in a piece of rectangular paper from  
the input image obtained by photographing the paper;

15 estimating a three-dimensional curved-surface  
model of the paper using distortion at an intersection  
of the horizontal and vertical character strings  
written in the paper as a clue; and

correcting the distortion based on the  
20 three-dimensional curved-surface model and outputting  
a corrected image as an output image.

29. A distortion correction method, comprising:

extracting an outline of a piece of rectangular  
25 paper from an input image obtained by photographing

the paper; and

correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image.

5

30. A distortion correction method, comprising:

obtaining outline information about a piece of rectangular paper and estimating a three-dimensional curved-surface model of the paper using outline distortion obtained from the outline information as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

15

31. A distortion correction method, comprising:

extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;

estimating a three-dimensional curved-surface model of the paper using distortion of the outline; and

correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image.

25

32. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting regular graphics attached to the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

15

33. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting an outline of the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the outline as a clue; and

25

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

5 34. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

10        extracting horizontal and vertical lines written in the paper from the input image;

             estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical lines written in the paper as a clue; and

15

             correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

20 35. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

25        extracting horizontal and vertical character

- strings written in the paper from the input image;  
estimating a three-dimensional curved-surface  
model of the paper using distortion at an intersection  
of the horizontal and vertical character strings  
5 written in the paper as a clue; and  
correcting the distortion based on the  
three-dimensional curved-surface model and outputting  
a corrected image as an output image.
- 10 36. A computer-readable storage medium, on which is  
recorded a program for enabling a computer to correct  
outline distortion of a piece of rectangular paper,  
included in an image obtained by photographing the paper,  
the program enabling the computer to perform:  
15 extracting an outline of the paper from the input  
image; and  
outputting a corrected image in which distortion  
of the outline is corrected.
- 20 37. A computer-readable storage medium, on which is  
recorded a program for enabling a computer to correct  
outline distortion of a piece of rectangular paper,  
included in input outline information about the paper,  
the program enabling the computer to perform:  
25 estimating a three-dimensional curved-surface

model of the paper using outline distortion obtained from the outline information as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting  
5 a corrected image as an output image.

38. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper,  
10 included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting an outline of the paper from the input image;

estimating a three-dimensional curved-surface  
15 model of the paper using distortion of the outline as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

20

39. A distortion correction device, comprising:

outline extraction means for extracting regular graphics attached to a piece of rectangular paper from an input image obtained by photographing the paper;

25 curved-surface estimation means for estimating



a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

distortion correction means for correcting the  
5 distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

40. A propagation signal for propagating a program to  
10 a computer for correcting outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting regular graphics attached to the  
15 paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

correcting the distortion based on the three-  
20 dimension curved-surface model and outputting a corrected image as an output image.